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The association of major patterns of physical activity, sedentary behavior and sleep with health-related quality of life: A cohort study ☆

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ABSTRACT

Objective. To examine the prospective association of patterns of physical activity, sedentary behavior and sleep with health-related quality of life (HRQL) in the general population of Spain.

Methods. A cohort study with 4271 individuals aged ≥18 years was recruited in 2008–2010 and followed-up prospectively through 2012. Activity patterns were derived from factor analysis. HRQL was assessed with the SF-12 questionnaire, and suboptimal HRQL was defined as a score below the sex-specific sample median.

Results. Three main activity patterns were identified. A higher adherence to the pattern named "vigorous activity-seated at the computer" was inversely associated with a suboptimal score in the physical-composite summary (PCS) of the SF-12 (multivariate adjusted odds ratio [aOR] for the highest vs. the lowest quartile 0.71; 95% confidence interval [IC] 0.55–0.90; p-trend = 0.003). The "light activity-seated for reading" pattern was inversely associated with a suboptimal score in the mental-composite summary (aOR = 0.73; 95% CI = 0.61–0.89; p-trend = 0.002). However, a higher adherence to the "seated for watching TV-daytime sleeping" pattern was directly associated with suboptimal PCS (aOR = 1.35; 95% CI = 1.10–1.66; p-trend = 0.008).

Conclusion. Patterns including any physical activity were associated with better physical or mental HRQL. However, a pattern defined by sedentary behavior with diurnal sleep showed worse HRQL and should be a priority target of preventive interventions.

Introduction

Health-related quality of life (HRQL) represents the individuals' perception of physical, mental and social health status. There is evidence that HRQL is a stronger predictor of mortality than many objective measures of health. Given that HRQL is a global health indicator, using HRQL as study outcome can provide newer insights into the effect of risk factors as compared to using only disease-specific endpoints. Moreover, because HRQL is a subjective measure, it might be useful as motivational instrument to promote the adoption of health behaviors. Lastly, since HRQL is a broad multidimensional concept, it allows us to define public policy interventions addressing a variety of areas, including the social, mental and medical services. (Centers for Disease Control and Prevention).

There is evidence that physical activity (PA) is directly associated with HRQL (Luncheon and Zack, 2011; Bize et al., 2007; Martin et al., 2009; Sorensen et al., 2011; Eriksson et al., 2010; Balboa-Castillo et al., 2011; Davies et al., 2012; Heesch et al., 2012), while sedentary behavior (SB) is inversely associated (Balboa-Castillo et al., 2011; Davies et al., 2012; Rhodes et al., 2012). SB, in particular, has been associated with poor physical and mental health after adjusting for physical activity (Balboa-Castillo et al., 2011). However, most of the studies on SB were cross-sectional (Davies et al., 2012), primarily focused on watching TV, and were very heterogeneous (Rhodes et al., 2012). Moreover, sleep duration, particularly short and long sleep, has been linked to worse HRQL in some studies (Faubel et al., 2009; Furihata et al., 2012; Lima et al., 2012).

However, since the total number of hours in a day is fixed and finite for an individual, participating in one activity results in not participating in another. For instance, individuals who engage more in SB usually devote less time to PA; or persons who spend more time playing basketball usually spend less time playing tennis. Consequently, the health

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effects of PA, SB and sleep duration depend not only on the specific activity, but also on the activities it displaces (Mekary et al., 2009). However, most studies on the impact of these three types of activities on HRQL do not directly account for these substitutions.

One method to address this issue is to summarize all activities across the day as activity patterns derived from the data (*a posteriori* patterns). This method is frequently used in nutritional epidemiology (Hu, 2002) and has served, for instance, to show that certain dietary patterns, such as the Prudent or the Mediterranean pattern, are associated with a lower risk of cardiovascular disease, while a Westernized dietary pattern is associated with a higher cardiovascular risk (Hu et al., 2000; Guallar-Castillon et al., 2012). Instead of looking at individual types of activities, pattern analysis examines the effect of overall physical activity; in fact, this type of analysis can account for substitution and interaction between PA, SB and sleep, as occurs in actual daily living, and goes beyond the somewhat artificial assessment of the independent (adjusted) effect of each of them. Conceptually, pattern analysis represents a broader picture of the time spent in different types of activities, and may thus be more predictive of health risks than each of them separately.

To our knowledge, however, no study has yet reported data on activity patterns based on the amount of time devoted to them. Therefore, this work has estimated these patterns and examined their prospective association with HRQL in the general population of Spain.

Methods

Study design and participants

The data were taken from the ENRICA study, whose methods have been reported elsewhere (Rodriguez-Artalejo et al., 2011). In brief, this is a cross-sectional study conducted from June 2008 to October 2010 with 12,948 persons representative of the non-institutionalized Spanish population aged 18 years and older. Data were collected in three stages: first, a phone interview using a structured questionnaire on socio-demographic variables, heath status, lifestyle, morbidity and health services use; second, a home visit to obtain biological samples (blood and urine); and third, another home visit to perform a physical exam and to conduct a dietary history. All persons who collected information (nurses to obtain biological samples, and non-health personnel for the rest of the tasks) received specific training in the study procedures.

Three years later (from May 2012 to January 2013), we attempted to contact a sample of study participants selected randomly, with overrepresentation of older adults. The sample consisted of 6207 individuals, and 4887 (78.7%) were successfully contacted. The socio-demographic, lifestyle and clinical characteristics were similar in subjects lost to follow-up and in those contacted, though differences reached statistical significance due to the large sample size (Table 1). At follow-up, data were collected through a phone interview conducted by trained staff. Data were analyzed in 2013.

Study participants gave written informed consent. The study protocol was approved by the Clinical Research Ethics Committees of the *La Paz* University Hospital in Madrid.

Patterns of physical activity/sedentary behavior/sleep

Habitual PA was assessed with the validated questionnaire developed in the EPIC-Spain cohort study (Pols et al., 1997). Specifically, participants were asked to indicate the number of hours during a usual week in the last year devoted to vigorous-intensity activities such as cycling (including commuting to work) and exercising (running, soccer, aerobics, swimming, tennis, gymnastics, etc.), separately for summer and winter. Additional information was obtained on the time spent walking (in commuting and in leisure time) and performing household chores (cleaning, washing, cooking, taking care of children, etc.), and the time devoted to gardening and do-it-yourself activities. In addition, the questionnaire of the Nurses' Health Study validated in Spain (Martinez-Gonzalez et al., 2005) was used to collect information on the time spent in six sedentary activities (seated while commuting, seated at the computer, seated while reading, seated and watching television, seated and listening to music, and seated or lying in the sun in summer and winter). We also collected information on the time spent seated while eating (breakfast, lunch and dinner). Lastly, the time spent sleeping was ascertained with the following questions: Can you tell me approximately how long you usually sleep at night? Can you tell me approximately how long you usually sleep during the day? Participants were asked to specify the number of hours and minutes they slept (Lopez-Garcia et al., 2008).

To identify patterns of PA, SB and sleep duration, we applied factor analysis (principal components) to the amount of time (minutes) devoted to each type of activity (Kleinbaum et al., 1988). This analysis generated various independent patterns (factors) made up of types of activities with a high degree of correlation. The factors were rotated by orthogonal transformation (Varimax rotation) (Kim and Mueller, 1978). Activity patterns to be retained for future analysis took into account their ease of interpretation, and required an eigenvalue >1 on the Scree test (a graphic representation where the patterns with eigenvalues >1 explain more variance than each individual activity). Factor loadings were obtained for each activity, making it possible for us to identify those most highly correlated with each pattern. Each subject received a score for each pattern, which was calculated as the sum of the time engaged in each activity weighted by the corresponding factor loading (Table 2). A higher score indicated a higher adherence to the respective pattern. The scores were classified in quartiles, where the highest quartile indicated a higher adherence to the activity pattern.

Health-related quality of life

HRQL was assessed with the SF-12 v.2 questionnaire, which has been validated in Spain (Schmidt et al., 2012). The 12 items of this questionnaire assess eight health dimensions: physical functioning, role-physical, bodily pain, general health, vitality, social functioning, role-emotional and mental health. Subjects' answers to any given item receive a numerical score which, after being coded, is then ranked on a scale of 0–100. Information on the eight health dimensions can

Table 1
Characteristics of subjects followed up and lost to follow-up in the study cohort.

	Lost to follow-up (N = 1320)	Followed up (N = 4887)	p value
Sex, %			
Men	47.5	49.2	0.264
Women	52.5	50.8	
Age, %			
18–29 years	16.8	11.4	<0.001
30–44 years	20.2	18.5	
45–64 years	24.5	31.8	
≥65 years	38.6	38.3	
Age, mean in years	53.4	54.3	<0.001
Level of education, %			
Primary or no formal education	42.8	38.0	<0.001
Secondary	36.6	35.8	
University	20.7	26.3	
Alcohol consumption, %			
Non-drinker	20.3	19.7	0.591
Moderate drinker	22.7	21.5	
Excessive drinker	45.7	47.7	
Former drinker	11.2	11.0	
Tobacco consumption, %			
Never smoker	48.1	49.5	0.009
Former smoker	25.4	27.8	
Current smoker	26.6	22.7	
Body mass index (BMI), %			
<25 kg/m^2	34.3	30.7	0.001
25–29.9 kg/m^2	38.3	44.0	
≥30 kg/m^2	27.4	25.3	
Physical activity during leisure time in METs h/week, mean	26.5	26.0	0.419
Adherence to Mediterranean diet (Trichopoulou Index), mean	4.3	4.4	0.011
Health-related quality of life			
Physical composite summary, mean	47.6	48.4	0.017
Mental composite summary, mean	49.7	51.0	<0.001
Chronic diseases, %[a]			
None	57.1	59.7	0.553
One	32.7	30.9	
Two	8.9	8.2	
Three or more	1.3	1.2	

[a] Including: chronic respiratory disease, coronary heart disease, stroke, osteoarthritis or arthritis, cancer, and diabetes mellitus.

Table 2
Time devoted to different activities and factor loadings for the three major physical activity, sedentary behavior and sleep patterns in the ENRICA cohort study (N = 4271).

		Factor loadings		
	Mean (SD) minutes/day	Vigorous PA-seated at the computer	Light PA-seated for reading	Seated for watching TV-daytime sleeping
Seated at the computer	47.3 (86.2)	0.62		
Performing vigorous physical activities	15.8 (24.2)	0.53		−0.24
Seated while commuting	27.8 (44.8)	0.48		
Seated or lying in the sun	11.3 (25.0)	0.38	−0.31	
Seated listening to music	11.4 (34.9)	0.38	0.15	0.20
Performing household chores	112.8 (119.8)	−0.53	−0.22	
Walking	52.8 (38.5)		0.59	
Seated for reading	43.7 (53.8)	0.17	0.57	
Gardening/do-it-yourself	9.6 (19.1)		0.48	
Seated during eating	59.5 (24.2)		0.38	
Day-time sleeping	16.9 (35.6)	0.21		0.71
Seated for watching television	129.2 (88.0)	−0.34		0.49
Night-time sleeping	418.4 (77.4)			−0.55

Factor loadings with absolute values <0.15 are not shown for simplicity. Varimax rotated factors are shown. SD: Standard deviation.

be summarized by two global HRQL indicators: the physical component summary (PCS) and the mental component summary (MCS). The PCS and MCS scores are standardized to a national norm with a mean of 50 and a standard deviation of 10; this allows comparison of the scores for each study participant against the mean score in the Spanish population. A higher score in each of the eight dimensions and in the PCS and MCS indicates a higher HRQL. For the purpose of this study, we defined suboptimal HRQL as a score below the sex-specific sample median in the health dimensions or its summaries.

Other variables

We used data on variables which could act as confounding factors of the study associations. Specifically, we used data on sex, age, level of education, alcohol and tobacco consumption. Also, weight, height and waist circumference were measured under standardized conditions (Gutierrez-Fisac et al., 2012). Body mass index (BMI) was calculated as weight in kg divided by the square of height in m, and study participants were classified into three groups: <25 kg/m^2 (normal weight); 25–29.9 kg/m^2 (overweight); and ≥ 30 kg/m^2 (obesity). Lastly, individuals reported the following physician-diagnosed diseases: chronic respiratory disease, coronary heart disease, stroke, osteoarthritis or arthritis, cancer at any site and diabetes.

Statistical analysis

Among the 4887 participants who were contacted during follow-up, 4780 were alive at the time of the interview. Of these, we excluded 444 individuals who lacked data on PA, SB, sleep duration or HRQL, and 65 with missing data on other variables. Thus, the analyses were conducted with 4271 individuals.

Unconditional logistic models were used to obtain odds ratios (OR) and their 95% confidence interval (CI) for suboptimal scores on each of the SF-12 dimensions and on the PCS or the MCS, according to quartiles of each pattern of PA, SB and sleep duration. A dose–response relationship was tested with a p for linear trend obtained by modeling the quartiles of pattern scores as a continuous variable. The models were adjusted for sex, age, level of education, consumption of alcohol and tobacco, BMI, reported morbidity, diabetes, and the corresponding SF-12 score at baseline. We tested whether study results varied with sex and age (18–44, 45–64, and ≥ 65 years) by using interaction terms, defined as the product of quartiles of pattern score by sex or age. Statistical significance was assessed with likelihood ratio tests which compared models with interaction terms and models without. Since no significant interactions were found, we report results for the total study sample.

Statistical significance was set at a 2-sided $p < 0.05$. Statistical analyses were conducted with Stata v.11.

Results

Three main patterns of PA/SB/sleep were identified. The first one was characterized by spending time sitting at the computer, doing vigorous PA and commuting to work; this pattern was also inversely associated with performing household chores and spending time seated watching TV (13% explained variance); this pattern was labeled as "vigorous PA-seated at the computer". The second pattern was characterized by longer time spent in walking, being seated for reading, and in gardening or do-it-yourself activities (10% explained variance); it was named as "light PA-seated for reading". The third pattern was characterized by daytime sleep (napping), spending time seated and watching TV; it was also inversely correlated with night-time sleep (9% explained variance) and was named as "seated for watching TV-daytime sleeping" pattern (Table 2). Compared to individuals in the lowest quartile of the "vigorous PA-seated at the computer" pattern, those in the highest quartile tended to be younger and had a lower frequency of chronic diseases, while the opposite was true for subjects in the other two patterns. The socio-demographic and clinical variables associated with each PA–SB–sleep pattern are shown in Table 3.

A higher adherence to the "vigorous PA-seated at the computer" pattern was associated with more optimal scores in the general health and the mental health scales on the SF-12 as well as with the PCS (OR 0.71; 95% IC 0.55–0.90; p-trend = 0.003) (Table 4). The "light PA-seated for reading" pattern was associated with better scores in three HRQL dimensions: physical functioning, vitality and mental health. Moreover, compared to those in the lowest quartile of this pattern, those in the highest quartile were less likely to have a suboptimal MCS (OR 0.73; 95% CI 0.61–0.89; p-trend = 0.002) (Table 5). Finally, an increasing adherence to the "seated for watching TV-daytime sleep" pattern was associated with increasing frequency of a suboptimal score on physical functioning and general health. Those in the highest quartile of the "seated for watching TV-daytime sleeping" pattern were more likely to have suboptimal PCS (OR 1.35; 95% CI 1.10–1.66; p-trend = 0.008) than those in the lowest quartile (Table 6).

Discussion

In this population-based cohort, we identified three patterns of PA, SB and sleep. Over the 3 year follow-up, greater adherence to the pattern "vigorous PA-seated at the computer" was associated with better physical health, and greater adherence to the pattern "light PA-seated for reading" was associated with better physical function and better mental health. In contrast, the pattern "seated for watching TV-daytime sleeping pattern" was associated with worse physical health.

Various analytic strategies can be used to assess the simultaneous affect of PA, SB and sleep on health. One such strategy is isotemporal substitution (Mekary et al., 2009; Balboa-Castillo et al., 2011), which evaluates the effect of replacing time spent on one activity (e.g., watching television or sleeping) with the same time spent on another activity (e.g., walking). The effect of belonging to various categories of these variables at the same time – that is, the *joint effects* – can also be evaluated (Sugiyama et al., 2008). However, since the time spent on different activities is correlated, and the effect of one activity on health may compensate for that of other activities, it is more

Table 3
Baseline characteristics of cohort participants according to quartiles of physical activity, sedentary behavior and sleep patterns (N = 4271).

	Vigorous PA-seated at the computer		Light PA-seated for reading		Seated for watching TV-daytime sleeping	
	Quartile 1	Quartile 4	Quartile 1	Quartile 4	Quartile 1	Quartile 4
Men, %	14.8	71.52	35.2	69.4	44.2	55.8
Age, %						
18–29 years	1.6	31.5	19.0	7.2	19.8	6.5
30–44 years	13.5	25.1	28.4	9.2	30.2	9.7
45–64 years	30.0	26.1	28.8	35.0	27.6	31.1
≥65 years	54.9	17.3	23.8	48.6	22.4	52.7
Level of education, %						
Primary or no formal education	64.3	11.8	36.9	31.6	23.6	50.9
Secondary	25.1	45.5	40.7	32.2	39.7	32.0
University	10.6	42.7	22.4	33.2	36.7	17.2
Alcohol consumption, %						
Non-drinker	35.1	9.0	23.3	14.2	17.2	21.1
Moderate drinker	20.8	25.8	25.1	20.4	25.1	19.6
Excessive drinker	30.6	57.1	40.8	55.4	46.7	48.2
Former drinker	13.5	8.1	10.8	10.0	11.0	11.2
Tobacco consumption, %						
Never smoker	67.1	41.3	50.6	45.4	50.9	48.7
Former smoker	17.4	30.2	21.1	33.5	26.0	28.3
Current smoker	15.6	28.6	28.3	21.1	23.1	23.0
Body mass index, %						
<25 kg/m^2	24.8	40.3	36.1	26.5	41.7	20.8
25–29.9 kg/m^2	45.0	40.4	38.1	48.9	41.7	45.8
≥30 kg/m^2	30.2	19.3	25.8	24.6	16.6	33.5
Chronic respiratory diseases, %	8.9	5.6	7.8	6.5	5.5	8.8
Coronary disease, %	1.1	0.8	0.9	1.5	0.4	1.3
Stroke, %	1.1	0.3	0.6	0.9	0.3	0.8
Osteoarthritis/arthritis, %	51.3	13.3	26.2	29.1	18.4	39.5
Cancer, %	1.2	1.0	0.8	1.5	0.4	2.6
Diabetes, %	12.4	5.3	7.4	12.0	5.1	15.0

appropriate to identify patterns of activities throughout the day instead of studying the independent effect of each. Furthermore, although activities may compete for the use of time, they can also have synergic effects that cannot be appreciated when estimating their independent effect.

Lord et al. recently characterized patterns of PA and SB measured by accelerometer in 56 older adults over a 7-day period (Lord et al., 2011). They obtained three patterns, which they called the “walking behavior pattern,” “sedentary behavior pattern” and “postural transitions pattern,” characterized by frequent changes in position from sitting to standing. However, this analysis was not based on the time spent on each activity, but rather on different characteristics like volume, frequency, intensity and variability of active and sedentary behaviors. Furthermore, the authors did not assess the association between the patterns obtained and HRQL.

Our study extends knowledge in this field because we assessed the time spent on 13 different types of activity, with different energy expenditures, which individuals can easily recognize. In addition, as opposed to traditional studies in the field of PA which included only PA and SB, this work also included sleep because it can be considered as one more activity.

The two patterns that included some type of PA, whether vigorous or light, were associated with better HRQL. This finding is in line with previous reports in the literature which have described a positive dose–response relationship (Martin et al., 2009; Samitz et al., 2011; Buman

Table 4
Odds ratios (95% confidence interval) for suboptimal score on the SF-12 scales according to quartiles of the “vigorous PA-seated at the computer” pattern.

Pattern “Vigorous PA-seated at the computer”	Physical functioning	Physical role	Bodily pain	General health	Vitality
Quartile 1 (lowest)	Ref.	Ref.	Ref.	Ref.	Ref.
Quartile 2	0.87 (0.70–1.08)	0.94 (0.78–1.15)	0.98 (0.80–1.19)	0.90 (0.68–1.17)	1.03 (0.84–1.26)
Quartile 3	0.96 (0.75–1.22)	0.83 (0.67–1.03)	0.84 (0.67–1.04)	0.75 (0.57–0.99)*	1.00 (0.80–1.24)
Quartile 4 (highest)	0.83 (0.63–1.10)	0.80 (0.63–1.02)	0.91 (0.72–1.16)	0.65 (0.49–0.88)*	1.05 (0.83–1.33)
p for trend	0.350	0.045	0.254	0.002	0.784
Pattern “Vigorous PA-seated at the computer”	**Social functioning**	**Emotional role**	**Mental health**	**Physical summary**	**Mental summary**
Quartile 1 (lowest)	Ref.	Ref.	Ref.	Ref.	Ref.
Quartile 2	0.98 (0.79–1.22)	1.04 (0.85–1.28)	0.78 (0.64–0.95)*	0.91 (0.74–1.11)	0.85 (0.71–1.03)
Quartile 3	0.94 (0.73–1.20)	0.88 (0.70–1.11)	0.85 (0.69–1.06)	0.78 (0.62–0.97)*	0.88 (0.72–1.08)
Quartile 4 (highest)	1.04 (0.79–1.37)	0.97 (0.75–1.26)	0.78 (0.62–0.99)*	0.71 (0.55–0.90)†	0.82 (0.66–1.03)‡
p for trend	0.910	0.528	0.114	0.003	0.145

N = 4271. Model adjusted for sex (man, woman), age (18–29 years; 30–44 years; 45–64 years; ≥65 years), level of education (primary or no formal education, secondary, university), tobacco consumption (never smoker, former smoker, current smoker), alcohol consumption (non-drinker, moderate drinker, excessive drinker, former drinker), body mass index (normal weight, overweight, obesity), personal history of chronic diseases at baseline: respiratory disease (no, yes), coronary heart disease (no, yes), stroke (no, yes), osteoarthritis/arthritis (no, yes), cancer (no, yes), diabetes mellitus (no, yes), and the corresponding SF-12 scale at baseline.

* $p < 0.05$.
† $p < 0.01$.
‡ $p < 0.001$.

Table 5
Odds ratios (95% confidence interval) for suboptimal score on SF-12 scales according to quartiles of the “Light PA-seated for reading” pattern.

Pattern “Light PA-seated for reading”	Physical functioning	Physical role	Bodily pain	General health	Vitality
Quartile 1 (lowest)	Ref.	Ref.	Ref.	Ref.	Ref.
Quartile 2	0.84 (0.67–1.06)	1.00 (0.83–1.22)	1.03 (0.85–1.24)	0.74 (0.59–0.93)*	1.05 (0.87–1.28)
Quartile 3	0.70 (0.53–0.84)†	0.96 (0.79–1.17)	0.91 (0.75–1.11)	0.69 (0.54–0.87)†	0.90 (0.74–1.09)
Quartile 4 (highest)	0.74 (0.58–0.94)†	0.90 (0.73–1.11)	0.96 (0.78–1.18)	0.84 (0.65–1.08)	0.76 (0.63–0.94)†
p for trend	0.003	0.298	0.470	0.118	0.003
Pattern “Light PA-seated for reading”	Social functioning	Emotional role	Mental health	Physical summary	Mental summary
Quartile 1 (lowest)	Ref.	Ref.	Ref.	Ref.	Ref.
Quartile 2	0.90 (0.73–1.12)	0.80 (0.66–0.97)	0.73 (0.60–0.88)‡	0.93 (0.76–1.14)	0.75 (0.63–0.90)†
Quartile 3	0.85 (0.68–1.05)	0.74 (0.60–0.91)	0.76 (0.62–0.93)†	0.83 (0.68–1.01)	0.75 (0.62–0.90)†
Quartile 4 (highest)	0.81 (0.63–1.02)	0.84 (0.68–1.05)	0.67 (0.54–0.82)‡	0.87 (0.71–1.08)	0.73 (0.61–0.89)†
p for trend	0.058	0.057	0.001	0.123	0.002

N = 4271. Model adjusted for sex (man, woman), age (18–29 years; 30–44 years; 45–64 years; ≥65 years), level of education (primary or no formal education, secondary, university), tobacco consumption (never smoker, former smoker, current smoker), alcohol consumption (non-drinker, moderate drinker, excessive drinker, former drinker), body mass index (normal weight, overweight, obesity), personal history of chronic diseases at baseline: respiratory disease (no, yes), coronary heart disease (no, yes), stroke (no, yes), osteoarthritis/arthritis (no, yes), cancer (no, yes), diabetes mellitus (no, yes), and the corresponding SF-12 scale at baseline.
* $p < 0.05$.
† $p < 0.01$.
‡ $p < 0.001$.

et al., 2010) between PA and HRQL (Heesch et al., 2012, 2011), and an inverse relationship of PA with cardiovascular disease (Li et al., 2013) and general mortality (Samitz et al., 2011). Among the mechanisms that can explain the better HRQL associated with PA are increased physical fitness (Rennie, 2005), reduction in cardiovascular risk factors (Carnethon et al., 2003), lower risk of functional limitation (Koster et al., 2009), frailty (Roubenoff and Hughes, 2000) and falls (Gillespie et al., 2009), enhancement of cardiorespiratory function (LeMura et al., 2000), increasing self-efficacy (McAuley et al., 2008), improved sleep quality (Yang et al., 2012), self-esteem (Joseph et al., 2014), and cognitive function (Plassman et al., 2010), and decreased risk of depression and anxiety (Barbour and Blumenthal, 2005; Petruzzello et al., 1991), as well as other chronic diseases (Chodzko-Zajko et al., 2009).

The pattern “light PA-seated for reading” was associated with better quality of life on both the physical and mental scales. This is relevant because the type of light PA considered in this pattern was walking, which is the easiest activity for most of the population and one that can benefit even older people and those with some functional limitation or disease (Taylor et al., 2004). There is also some evidence that activities that include reading have a beneficial effect on mental health (Dowrick et al., 2012; Hodge et al., 2007).

The pattern “seated for watching TV-daytime sleeping” was associated with poorer physical health. This pattern included sleeping during the day and sleeping little at night. Both short night-time sleep duration and long night-time sleep duration have been associated with a greater risk of cardiometabolic disease (Alvarez and Ayas, 2004) and general mortality (Gallicchio and Kalesan, 2009). People with mild insomnia also have poorer physical and mental health than good sleepers (Leger et al., 2001). Moreover, aerobic PA and sleep hygiene education improve HRQL in patients who have difficulty sleeping at night (Reid et al., 2010). On the other hand, there is evidence that watching TV and doing little vigorous PA are associated with obesity and other cardiovascular risk factors (Jakes et al., 2003) that could mediate the effect of this pattern on HRQL. A positive association has also been established between watching TV and multiple adverse health outcomes in adults (Thorp et al., 2011; Sidney et al., 1996), even among those who meet the PA recommendations (Healy et al., 2008).

Table 6
Odds ratios (95% confidence interval) for suboptimal score on SF-12 scales according to quartiles of the “Seated for watching TV-daytime sleeping” pattern.

Pattern “Seated for watching TV-daytime sleeping”	Physical functioning	Physical role	Bodily pain	General health	Vitality
Quartile 1 (lowest)	Ref.	Ref.	Ref.	Ref.	Ref.
Quartile 2	1.21 (0.96–1.53)	0.91 (0.74–1.11)	0.84 (0.69–1.01)	1.08 (0.87–1.34)	1.10 (0.91–1.32)
Quartile 3	1.14 (0.90–1.44)	1.00 (0.82–1.22)	0.86 (0.71–1.05)	1.04 (0.83–1.30)	1.12 (0.92–1.36)
Quartile 4 (highest)	1.65 (1.30–2.09)‡	1.15 (0.94–1.41)	1.02 (0.84–1.26)	1.32 (1.03–1.70)*	1.18 (0.96–1.44)
p for trend	<0.001	0.105	0.701	0.060	0.119
Pattern “Seated for watching TV-daytime sleeping”	Social functioning	Emotional role	Mental health	Physical summary	Mental summary
Quartile 1 (lowest)	Ref.	Ref.	Ref.	Ref.	Ref.
Quartile 2	1.00 (0.80–1.26)	0.87 (0.71–1.08)	0.91 (0.75–1.09)	1.10 (0.91–1.34)	0.96 (0.80–1.15)
Quartile 3	1.06 (0.84–1.40)	0.94 (0.76–1.16)	1.05 (0.87–1.28)	1.09 (0.89–1.33)	1.08 (0.90–1.30)
Quartile 4 (highest)	1.19 (0.95–1.51)	1.14 (0.92–1.41)	1.10 (0.90–1.34)	1.35 (1.10–1.66)†	1.06 (0.87–1.28)
p for trend	0.114	0.170	0.200	0.008	0.355

N = 4271. Model adjusted for sex (man, woman), age (18–29 years; 30–44 years; 45–64 years; ≥65 years), level of education (primary or not formal education, secondary, university), tobacco consumption (never smoker, former smoker, current smoker), alcohol consumption (non-drinker, moderate drinker, excessive drinker, former drinker), body mass index (normal weight, overweight, obesity), personal history of chronic diseases at baseline: respiratory disease (no, yes), coronary heart disease (no, yes), stroke (no, yes), osteoarthritis/arthritis (no, yes), cancer (no, yes), diabetes mellitus (no, yes), and the corresponding SF-12 scale at baseline.
* $p < 0.05$.
† $p < 0.01$.
‡ $p < 0.001$.

This study has some limitations and strengths. Among the former are the fact that the data were self-reported, therefore we cannot rule out some overestimation of PA and underestimation of SB for reasons of social desirability (Celis-Morales et al., 2012). This would have underestimated the beneficial impact of PA on HRQL. Another limitation is that, as in other “a posteriori” analyses, there may be some subjectivity in the labeling of the patterns; furthermore, the patterns of PA/SB/sleep may be population-specific, therefore our results should be confirmed in other countries.

Among the strengths of the study are its prospective design, the large size of the cohort, and the inclusion of a large number of activities that make up the patterns. In addition, the main study variables were measured with validated instruments, widely used in the literature. Finally, the analyses were adjusted for numerous confounding factors, including lifestyles and chronic diseases.

This work has some practical implications. First, the patterns described are easily recognizable by the population. This can make it easier for individuals to understand that PA, SB and sleep represent a continuum in the use of time, and that all three types of activity influence HRQL. Second, individuals with greater adherence to the pattern “seated for watching TV-daytime sleeping” should be a priority target for preventive interventions. Third, the patterns that include PA are associated with better HRQL, both physical and mental. This is important because PA can delay the decrease in physical HRQL associated with age, and because some other strategies to improve mental health (e.g., supportive personal relationships or control of work stress) may not be possible in all people. Fourth, the fact that PA can improve HRQL in a relatively short time (e.g., in only 3 years) means it is especially relevant in older adults because they have lower life expectancy. Finally, adopting the pattern that includes just light PA (e.g., walking) can provide benefits for any age and sex, regardless of whether the individual suffers from a chronic disease. This is notable because a substantial proportion of participants were elderly persons with chronic diseases, for whom walking is a simple way to perform light PA.

Contributors

PG-C conceived the study. PG-C, AB-B and FR-A drafted the manuscript and are the guarantors. PG-C, AB-B and LML-M analyzed the data. All authors interpreted the results and contributed to writing the manuscript. PG-C and AB-B take responsibility for the integrity of the data and the accuracy of the data analysis.

Conflict of interest statement

The authors declare that there are no conflicts of interests.

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